

EXPLORING THE EFFECTIVENESS AND IMPACTS OF DIFFERENT TYPES OF MEDIA IN SCIENCE LEARNING

Yi Wen Lo , Chih-Hsiung Ku

National Dong Hwa University, Taiwan

E-mail: s88b1025@gmail.com, chku@gms.ndhu.edu.tw

Abstract

The spread of COVID-19 has caused a high demand for online learning or self-learning at home. We focus on evaluating which media is most suitable for self-learning for the third graders. For effective assessment of children's learning, the study adopted AEIOU: Awareness; Enjoyment; Interest; Opinion formation; and Understanding as the evaluation framework.

In this research, three types of media were implemented: animation, educational video, and science comics. Total 145 third graders were divided into three groups: animation group, educational video group, and science comics group, to learn the concept of heat transfer through one kind of media respectively. The results revealed that students had positive feedback on the three dimensions of Awareness, Enjoyment, and Interest. And all three media improved students' understanding of heat transfer without a difference. While in the dimension of Opinion formation, the students had less life experience and pre-knowledge, their performances were relatively low. In summary, the three types of media showed the effectiveness of self-learning for the third graders. Especially the animations proved to be the most suitable for the third-grade children to conduct self-learning.

Keywords: science communication, AEIOU, heat transfer, Media

Introduction

Background and Research Purposes

Since the spread of COVID-19 in 2019, countries have begun to adopt different lockdown measures as the epidemic has become more and more severe. This includes decisions that affect education such as closing schools, suspension of schools, suspension of classes, and so on. António Guterres (2020), the ninth secretary-general of the United Nations, also pointed out: As of mid-July 2020, more than 1 billion students have been affected by the suspension, which results in at least 40 million children not able to attend preschool. Such learning crisis may cause "generational catastrophe". Therefore, the needs of using media for online self-learning and self-learning at home have arisen. Regarding online or home-based self-learning, it is necessary to use media to deliver the information. This study aimed to investigate which type of media can convey the concept of heat transfer to elementary school students most efficiently? Which types of media are elementary school students more interested in? Previous studies reported that the use of media should also consider how to communicate efficiently. The function

of media is not only to deliver the scientific information, but also to shape scientific information (Dimopoulos & Koulaidis, 2002). If media can correctly disseminate scientific information, it can improve the public's judgments and enable them to illustrate ideas clearly when participating in the discussion of scientific issues. In addition, it encourages the public to actively participate in the formulation of science and technology policies (Chin & Chen, 2007; Norris & Phillips, 2003). In order to correctly evaluate the effectiveness and impacts of different types of media used, it is necessary to first explore the definition of science communication, to understand which aspects can be used to evaluate the purpose of this research and develop evaluation instruments.

Science Communication

As the well-known Bodmer Report (The Royal Society, 1985) highlighted the issue of the insufficient scientific knowledge in public, the public began to realize that it might affect the development of science, and this resulted in several waves of research and discussion on science communication. Since the 1990s, the main model for research and practice of science communication has changed from the deficit models to the engagement models (Wynne, 1992; Sturgis & Allum, 2004). The deficit models emphasized the one-way knowledge transmission from teachers to students, stating that if the public does not have sufficient scientific knowledge, it will indirectly affect the support for science. On the other hand, the engagement models advocated that the decision-making of public issues be participated by the public in two-way communication, as opposed to the past decision-making style dominated by the experts (Hung, 2017). From this point of view, related scholars in science communication believe that the public must be able to make more meaningful decisions when facing science-related issues in society. Therefore, the public should have more and more extensive conversations with teachers or scientists, not just receiving knowledge (Baram-Tsabari & Osborne, 2015). To be able to effectively evaluate the effectiveness of a two-way communication, the definition of science communication must first be clearly stated.

Burns et al. (2003) stated that the boundary between the definition of science communication and the terms used in the field of scientific literacy was blurred. In view of this, Burns et al. (2003) pointed out the ambiguity between the definition of science communication and the terms used in the field of scientific literacy. In view of that, Burns et al. (2003) compiled a list of elements used in a two-way communication model (e.g., engagement model), for example: public awareness of science (PAS), public understanding of science (PUS), scientific culture (SC), or scientific literacy (SL), etc., and further listed the definitions that are suitable for the science communication. When there is a definition of the science communication, it cannot only promote science, but also serve as a basis for evaluating the effectiveness of science communication.

Theoretical Framework

Burns et al. (2003) defined science communication as “the use of appropriate skills, media, activities, and dialogue to produce one or more personal responses to science” (p.191). These responses are classified into five categories (the AEIOU vowel analogy): Awareness, Enjoyment, Interest, Opinion formation, and Understanding. AEIOU can be

used as the common goal of science communication and science education. It also provides a framework for this research to evaluate the effectiveness of science communication, which can be used to analyse the public's response to science communication activities or experiences. The details of each category are described below.

- (1) Awareness: For science, it provides a basis for knowledge, broadens thinking, and creates opportunities for individuals to participate in scientific activities (Burns et al., 2003). Awareness of science is an important consideration for the public to participate in science communication activities. This study defines awareness as being aware of the importance of science and technology and being able to understand nature of science.
- (2) Enjoyment: Enjoyment may evoke positive feelings and attitudes of participants, so that participants are more likely to produce subsequent and in-depth scientific activities (Stocklmayer & Gilbert, 2002). This research regards enjoyment as the pleasant life experience brought by today's technology.
- (3) Interest Krapp et al. (1992) stated that innovation and appropriate scientific communication activities can inspire the personal interest of participants. This activity can also stimulate participants' interest in the situation and further enhance participants' recall and understanding of the event. This research regards interest as the tendency and intention to participate in scientific issues, events, or activities.
- (4) Opinion formation: Opinions are closely related to knowledge, beliefs, and emotional responses, and are deeply influenced by them (Crawley & Koballa, 1994). Therefore, this part of the research is not easy to implement. The most effective science communication one can produce is for participants to reflect on, form, reform or confirm their attitudes towards science and society (Burns et al., 2003). In this research, the formation of opinions is defined as opinions or viewpoints formed in the reflection of the public to support their arguments on certain scientific issues.
- (5) Understanding: Understanding of science includes comprehension of scientific content, processes, and social factors (Burns et al. 2003). It emphasizes the application and meaning of science. This research defines this understanding as the understanding of the acquired scientific knowledge.

Science communication is committed to enhancing the awareness of science, scientific understanding, scientific literacy, and scientific culture through the AEIOU responses established by participants (Burns et al., 2003).

Research Methodology

Background

This research adopted a quasi-experimental design, the purpose was to explore the impacts and effectiveness of using different media to illustrate the concept of heat transfer among the third-grade students in elementary school. The participants of this study were six classes of the third-grade students, later divided into three groups: two classes were animation group, two classes were educational video group, and two classes were science comic group. Each group was used for three standard class periods which

were 120 minutes in total. Based on AEIOU as the evaluation framework, each group conducted the pre-test of Understanding test, and then watched the media of each group. The media materials included animations, educational videos, and science comics that were all about the concept of heat transfer. Afterward, the groups performed the post-test of Understanding test; subsequently, each group had to watch or read the other media. After watching or reading all three media, students would take the AEIO questionnaire. Finally, statistical analysis on the quantitative results of the AEIOU was used, for the open-ended responses from O need to be coded before analysis.

Participants

A total of six classes of third-grade students in an elementary school in Taiwan were chosen as participants ($N = 145$) with an average age of 9 years old. This research used a cluster sampling. The two classes were treated as one group, and six classes were divided into three groups: animation group, educational video group, and science comic group. There were 49 people in the animation group, 48 people in the educational video group, and 48 people in the science comic group. Before the experiment teaching, all the participants had not been exposed to the related concepts of heat transfer. Because of the small scale of samples, the inference of the research results was limited, and it was only suitable for the students who infer to the sample of this study and situations similar to this research. To infer this research results to other groups or educational fields, the applicability needs to be evaluated carefully.

Introduction of media used in the experiment

This study used three different media; the description of these media is as follows:

- (1) Animation: In 1980, the International Association of Film Animation (ASIFA) defined animation as "in addition to real actions or methods, various techniques are used to artificially create dynamic images" (Liu, 2009). The animation materials used in this study were from Junyi Academy website, which is a non-profit educational organization in Taiwan that uses an online learning model. This website focuses on providing equal and high-quality educational resources for every child, and through technological instruments to help teachers and parents to teach in accordance with learners' aptitude. Thus, let children develop the habit of self-learning and become life-long learners (Junyi, 2021). Since the animation playback will be paused during the question time, it will continue to play only after the question is answered, which increases the opportunities for online self-learning and interaction.
- (2) Educational Video: The educational video provides both sound and image elements at the same time. Learners can use the continuous sound and images to more easily understand the details that originally required a lot of text description. The educational video does not have an interactive design, and the learners receive the video information unidirectionally, and the learning process is relatively boring (Huang, 2014). The educational videos used in this research are specially filmed with textbook content. The advantage of the educational videos is a direct presentation of a realistic situation. With narration, text, and simple symbols (such as arrows), the teaching content can be presented simply and clearly, and the learners will be more deeply impressed.

- (3) Science Comic: Xiao (2002) has made a simple analysis of the composition of comics, dividing the elements of comics into four parts: "image", "text", "frame", and "story". The Science Comics used in this research refers to comics that contain scientific elements, and "The King of Science Experiments (10)-The Flow of Heat" was used as the reading material for the science comics group.

The King of Science Experiments is published by San Cai Publishing House. It was originally a South Korean comic and has now been translated into Chinese. This set of books takes "competition for experimentation" as the main plot, and the protagonist participates in the experiment competition and brings out learning knowledge. In addition to comics throughout the book, there are also collocation articles to tell scientific knowledge. However, the scientific knowledge content of this book is relatively less. The whole book contains 200 pages of text, 183 pages of comics, 17 pages of scientific articles, and 15 pages of knowledge related to heat transfer.

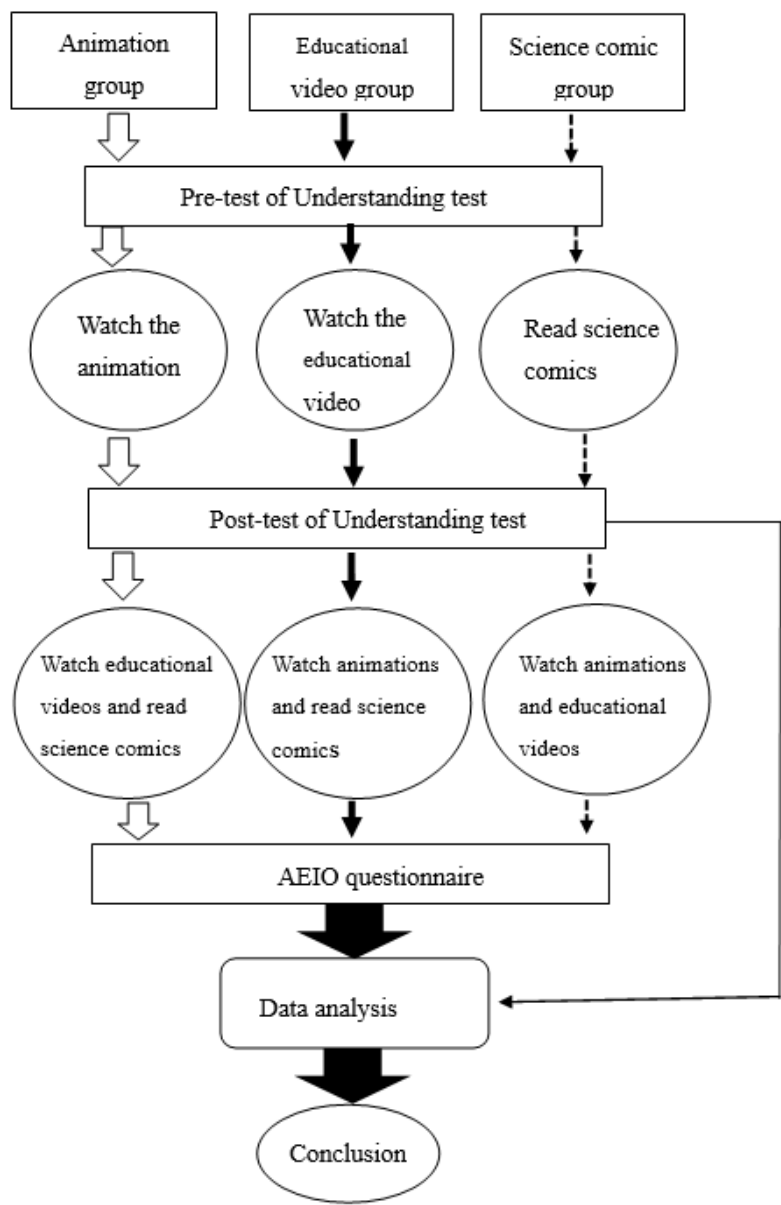
Table 1
The Media Used in the Experiment

Media type	Source	Heat transfer conception	Time
Animation	Junyi academy website	heat conduction heat convection heat radiation	10 minutes 58 seconds
Educational Video	Online resources produced by textbook publishers	heat conduction heat convection heat radiation	10 minutes 36 seconds
Science Comics	The King of Science Experiments (10)	heat conduction heat convection (Note: Another heat radiation article is attached)	30 minutes

Research Procedure

After dividing the students into three groups, all three groups first accepted the pre-test of the Understanding test. After that, the Animation group first accepted the animation viewing, the Educational Video group first watched the educational video, and the Science Comics group first read The King of Science Experiments (10). After the first step was finished, all students would conduct the post-test of the Understanding test. After the post-test, each group needed to watch or read the other two media, for example: The Animation group needed to watch the educational video and read science comics. After watching or reading all the media, the AEIO questionnaire would be implemented.

Figure 1
The Summary of Research Procedure



Assessment instruments

- (1) The AEIO questionnaire was adapted from a Scale for Science Edu-Communication (Wu et al., 2019). The scale had undergone statistical tests and had proven to be a valid and reliable instrument to measure the effectiveness of science communication. The validity of AEIO questionnaire was established by expert judgment, and we used SPSS 17 to run test-

retest analysis of AEI dimensions. The Pearson's correlation coefficient was $0.916 > 0.7$, so the AEI questionnaire had a high degree of reliability. The data of Opinion formation was qualitative, so the reliability test was not performed.

- (2) This study designed 31 items of heat transfer at first, and then 49 students in the third grade were chosen to undertake the preliminary examination. According to the results of preliminary examination, some items were rejected due to their poor discrimination index. Finally, there were 16 items in the Understanding test.

Table 2
Question Types of AEIOU and Number of Items

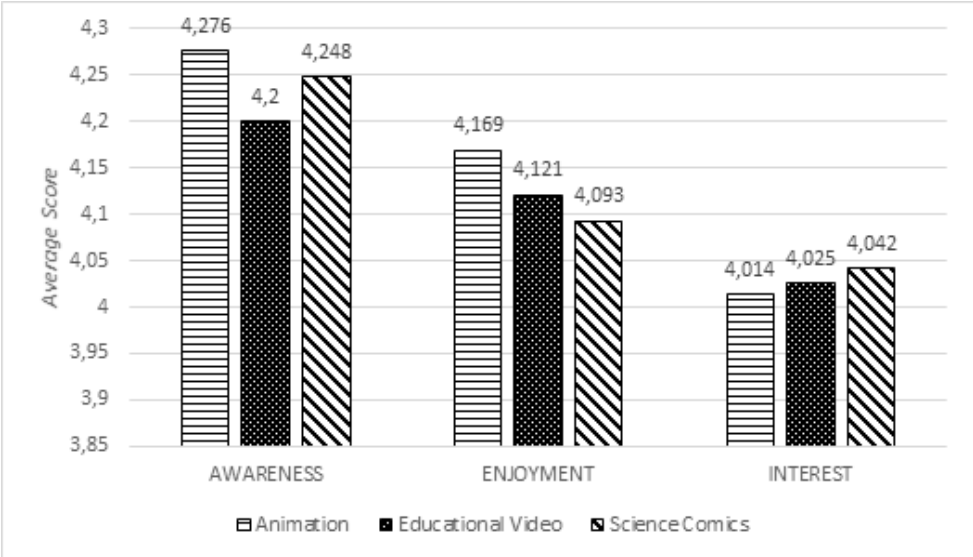
AEIOU Dimensions	Number of Items	Question Type
Awareness	6	5-point Likert scale
Enjoyment	6	
Interest	6	
Opinion formation	1	Open-Ended
Understanding	16	Yes/No Questions and Multiple-Choice Questions

Research Results

AEI Questionnaire

A 5-point Likert scale was used to measure AEI dimensions. The scoring of AEI was from 1 point (completely disagree) to 5 point (completely agree) with a higher total score designating higher levels of AEI. Based on the above calculation of the average score and the analysis result, it was found that the average score of the AEI dimensions was above 4. This data showed that no matter what kind of media teaching, students had a positive attitude towards AEI dimensions. Among them, Awareness had the highest score of 4.241. This study also analysed the impact of three media on AEI dimensions. Among the three media, the animation group got the highest average score in the two dimensions of Awareness and Enjoyment, and the science comic group had the highest average score in the Interest dimension.

Figure 2
An Average Score of Different Media on the AEI Questionnaire



Open-Ended Questions of Opinion Formation

The question of Opinion formation was that” if you have a house, what can you do to make the people feel cooler in the house? Please try to explain from the installation of air-conditioning, the treatment of the wall, the position of the window, etc.” After integrating the answers, it was found that because the third-grade students had a limited vocabulary and insufficient discussion skills, the proportion of answers was not high and only short words were answered. The answers of Opinion formation were coded and analysed, they were divided into heat conduction group, heat convection group, heat radiation group and error groups.

Table 3
Analysis of the Answers of Opinion Formation

Group	Examples of answers	Number of Students	Ratio
Heat Conduction	N/A	0	0%
Heat Convection	The air-conditioning is installed on the ceiling, above the room, and windows are installed on the left and right sides of the house, etc.	49	29.7%
Heat Radiation	Painted white walls	33	20%
Error	Did not write, air-conditioning installed next to the TV, win- dows installed next to the door, etc.	83	50.3%

Note: The question can have more than one answer, so the calculation of the ratio is the number of students with a certain answer / total number of answers

From the results, we know that students were more familiar with the concept of heat convection and have a higher rate of correct answers. However, the students may be influenced by the question, so they did not answer in the aspect of heat conduction at all. Basically, the third-grade students may be limited by insufficient life experience, insufficient language skills, insufficient scientific knowledge, and other factors, so their performance in Opinion formation was bad.

Understanding Test

In order to compare the post-test scores influenced by the three groups of media, we used the analysis of One-Way ANOVA (Lin, 2014) to determine whether there were any statistically significant differences between the means of three groups. After the analysis of One-Way ANOVA (by SPSS 17), the F value was 0.208, and the significance value was 0.812($p = .812$) which was above 0.05. Therefore, there was no statistically significant difference in the three groups of media. Thus, the three groups of media had no significant influence on the post-test scores of the Understanding test.

Then, we used the analysis of the Paired-Sample t Test (Lin, 2014) to compare the influence on post-test scores by each medium. In the animation group, the significance value was 0.008($p = .008$) which was below 0.05, and the average post-test score was higher than the average pre-test score, indicating that watching animations can significantly improve the understanding of science. In the educational video group, the significance value was 0.03($p = .03$) which was below 0.05, and the average post-test score was higher than the average pre-test score, indicating that watching educational videos can significantly improve the understanding of science. And in the science comic group, the significance value was 0.047($p = .047$) which was below 0.05, and the average post-test score was higher than the average pre-test score, indicating that reading science comics can significantly improve the understanding of science.

Integrating the above data shows that no matter what kind of media can improve the participants' understanding of science.

Brief Summary

To summarize the above results, we can know that the animation group get the highest average score in the two dimensions of Awareness and Enjoyment, and the science comic group have the highest average score in the Interest dimension. On the dimension of Understanding, the analysis results of the three media show no significant differences, meaning that there is no difference in the impact of the three media on the post-understanding test. Afterward, the Paired-Sample t-Test of each media was carried out. The results show that the P-value of each material is less than 0.05, and all of the average scores of the post-test are higher than the average score of the pre-test, meaning that each media has a significant improvement in student's Understanding. As for Opinion Formation, because the subjects are young, they may have insufficient life experience, insufficient scientific knowledge, poor language skills, etc., which results in very few answers, or more than half of the students did not answer. In conclusion, the third-grade students do not perform well in Opinion Formation.

Conclusions and Implications

The spread of COVID-19 has caused a high demand for online learning or self-learning at home. We focus on evaluating which media is most suitable for self-learning for the third-grade students. To effectively evaluate the learning effectiveness, this study uses the five aspects of response to science communication as the evaluation framework. These five responses are: Awareness, Enjoyment, Interest, Opinion formation, and Understanding.

In this research, three types of media have been discussed: animation, educational video, and science comic. The first two are network resources, while the last is physical books. Throughout the experiment, the teacher played the role of observer, and was no longer the transmitter of knowledge. Only in this way could it be in line with the self-learning situation. Finally, the results pointed out that after the students used the three media, the third-grade students had positive feedbacks on the three dimensions of Awareness, Enjoyment, and Interest, among which Awareness scored the highest. Next, this study analysed the influence of the three media on AEI. Among them, the animation got the highest score in the two dimensions of Awareness and Enjoyment, and the science comic group got the highest score in the dimension of Interest. As for the dimension of Opinion formation, because the third-grade students are relatively young and have insufficient life experience and scientific knowledge, the response is poor. Nonetheless, all three media can improve students' understanding of science, and there is no difference between them.

In summary, the three types of media showed the effectiveness of self-learning for the third graders. Especially the animations proved to be the most suitable for the third-grade children to conduct self-learning. For the older students, the media that is suitable for self-learning may be changed, which requires further research.

Declaration of Interest

Authors declare no competing interest.

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